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Section	A
Paper	Hydraullic Engr
Semister	6th

QNO.1):

Solution:

As we know pressure drop Δp depends on h, d, V, ρ and μ.

ΔP	$ML^{-1}T^{-2}$
h	L
d	L
V	LT^{-1}
ρ	ML^{-3}
μ	$ML^{-1}T^{-1}$

No. of variables $n=6$

No. of Independent dimension $m=3$ $(M, L \text{ and } T)$

No. of non-dimensional groups; $n-m=6-3$ $=3$

Choose $m=3$ scaling variables;

geometric (d); Kinematic/time-dependent(V); dynamic/mass-dependent(ρ)

For Non-dimensionalising Δp, h and μ.

$$\Pi_1 = \Delta p d^a V^b \rho^c$$

$$M^0 L^0 T^0 = (ML^{-1}T^{-2})(L)^a(LT^{-1})^b(ML^{-3})^c$$

$$= M^{1+c} L^{-1+a+b-3c} T^{-2-b}$$

$M:$ $0=1+c$ $\Rightarrow c=-1$

$T:$ $0=-2-b$ $b=-2$

$L:$ $0=-1+a+b-3c$ $a=1+3c-b=0$

$$\Pi_1 = \Delta p V^{-2} \rho^{-1} = \frac{\Delta P}{\rho V^2}$$

$\Pi_2 = \frac{h}{d}$ (Here "h" is length)

$\Pi_3 = \mu d^a v^b \rho^c$

$M^0L^0T^0 = (ML^{-1}T^{-1})(L)^a(LT^{-1})^b(ML^{-3})^c$

$= M^{1+c}L^{-1+a+b-3c}T^{-1-b}$

M: $0 = 1 + c \Rightarrow c = -1$

T: $0 = -1 - b + 0 \Rightarrow b = -1$

L: $0 = -1 + a + b - 3c \Rightarrow a = 1 + 3c - b = -1$

$\Pi_3 = \mu d^{-1} v^{-1} \rho^{-1} = \frac{\mu}{\rho v d}$

By Renolds number We replace Π_3 by

$\Pi_3' = (\Pi_3)^{-1} = \frac{\rho v d}{\mu}$

By dimensional analysis yields

$\Pi_1 = f(\Pi_2, \Pi_3')$

i-e

$$\frac{\Delta P}{\rho v^2} = f\left(\frac{h}{d}, \frac{\rho v d}{\mu}\right)$$

(a) Dynamic similarity requires thall all non-dimensional groups be the same in model and prototypes

$\Pi_1 = \left(\frac{\Delta P}{\rho v^2}\right)_p = \left(\frac{\Delta P}{\rho v^2}\right)_m$

$\Pi_2 = \left(\frac{h}{d}\right)_n = \left(\frac{h}{d}\right)_m$

Hence they have similar shape i-e (geometric similarity)

$$\Pi_3' = \left(\frac{\rho V d}{\mu}\right)_p = \left(\frac{\rho V d}{\mu}\right)_m$$

As velocity ratio

$$\frac{V_p}{V_m} = \frac{(\mu/\rho)_p}{(\mu/\rho)_m}\,\frac{d_m}{d_p} = \frac{0.002/800}{1.0\times10^{-6}} \times \frac{1}{5} = 0.5$$

Hence

$$V_m = \frac{V_p}{0.5} = \frac{3.0}{0.5} = 6.0\ \text{m s}^{-1}$$

(b) Ratio of quantities of flow is

$$\frac{Q_p}{Q_m} = \frac{(V\times A)_p}{(V\times A)_m} = \frac{V_p}{V_m}\left(\frac{d_p}{d_m}\right)^2 = 0.5\times5^2$$

$$\frac{Q_p}{Q_m} = 12.5$$

(c) For pressure drop

$$\Pi_1 = \left(\frac{\Delta P}{\rho V^2}\right)_p = \left(\frac{\Delta P}{\rho V^2}\right)_m$$

$$\Rightarrow \frac{(\Delta P)_p}{(\Delta P)_m} = \frac{\rho_p}{\rho_m}\left(\frac{V_p}{V_m}\right)^2$$

$$= \frac{800}{1000} \times 0.5^2$$

$$= 0.2$$

Hence

$$\Delta P_p = 0\ 2 \times \Delta P_m = 0.2 \times 60 = 12.0\ \text{KPa}$$

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Q NO. 2):

Solution:

Max depth of water in the reservior = H = 77

Specific Gravity of dam material
$G = 3.4$

Allowable Compressive strength of dam Masonary = 779 T/m^2

Height of wave $H_W = 2.2m$
$\mu = 0.7$, $C_u = 0$

① $$H_{limiting} = \frac{G_{all}}{\gamma_w(G - C_u + 1)} = \frac{779 \times \cancel{1000}}{\cancel{1000}(3.4 - 0 + 1)}$$
$$= 324.583m > H_W = 77$$

So it is low Gravity dam.

② Top width "a"

Free board = $1.5 h_{wave} = 1.5 \times 2.2$

$$\boxed{F.B = 3.3m}$$

height of Dam = $H_D = H_W + F.B$
$= 77 + 3.3$

$$\boxed{H_D = 80.3m}$$

$a = 14\%$ of H_D

$a = 0.14 \times 80.3$

$$\boxed{a = 11.24m}$$

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3) Base width "b" (without off set)

(i) For No Sliding criteria.

$$b' = \frac{Hw}{\mu G} = \frac{77}{0.7 \times 3.4}$$

$$b' = 32.35$$

$$\boxed{b' = 32.4}$$

(ii) For No tension criteria

$$b' = \frac{Hw}{\sqrt{G}} = \frac{77}{\sqrt{3.4}}$$

$$b' = 41.8\ m = 42\ m$$

use $\boxed{b' = 42}$

④ Depth of vertical portion on u/s side.

$$h' = 2a\sqrt{G - Cu}$$

$$h' = 2 \times 11.24\sqrt{3.4 - 0}$$

$$h' = 41.45$$

$$\boxed{h' = 42\ m}$$

⑤ upstream off set $= \frac{a}{16}$

$$= \frac{11.24}{16}$$

$$= 0.7025\text{m}$$

⑥ Depth below the water level to the end of inclined portion in U/S $= 3.14\, a\sqrt{G}$

$$= 3.14 \times 11.24\sqrt{3.4}$$

$$= 65.07\,m$$

⑦ total width of the base of dam,

$$b = b' + \frac{a}{16} = 42 + 0.7025$$

$$\boxed{b = 42.7025\,m}$$

⑧ $\tan\theta = \frac{b'}{H} = \frac{42}{77}$

$$\theta = \tan^{-1}(0.54)$$

$$\boxed{\theta = 28.37^\circ}$$

⑨ Depth of vertical portion on D/s (from WL on U/S side)

$$\tan\theta = \frac{a}{d'} = \frac{11.24}{d'}$$

$$\tan\theta = \frac{11.24}{d'}$$

$$\frac{42}{77}\, d' = 11.24$$

$$d' = \frac{11.24 \times 77}{42}$$

$$\boxed{d' = 20.6\ m}$$

depth of vertical portion

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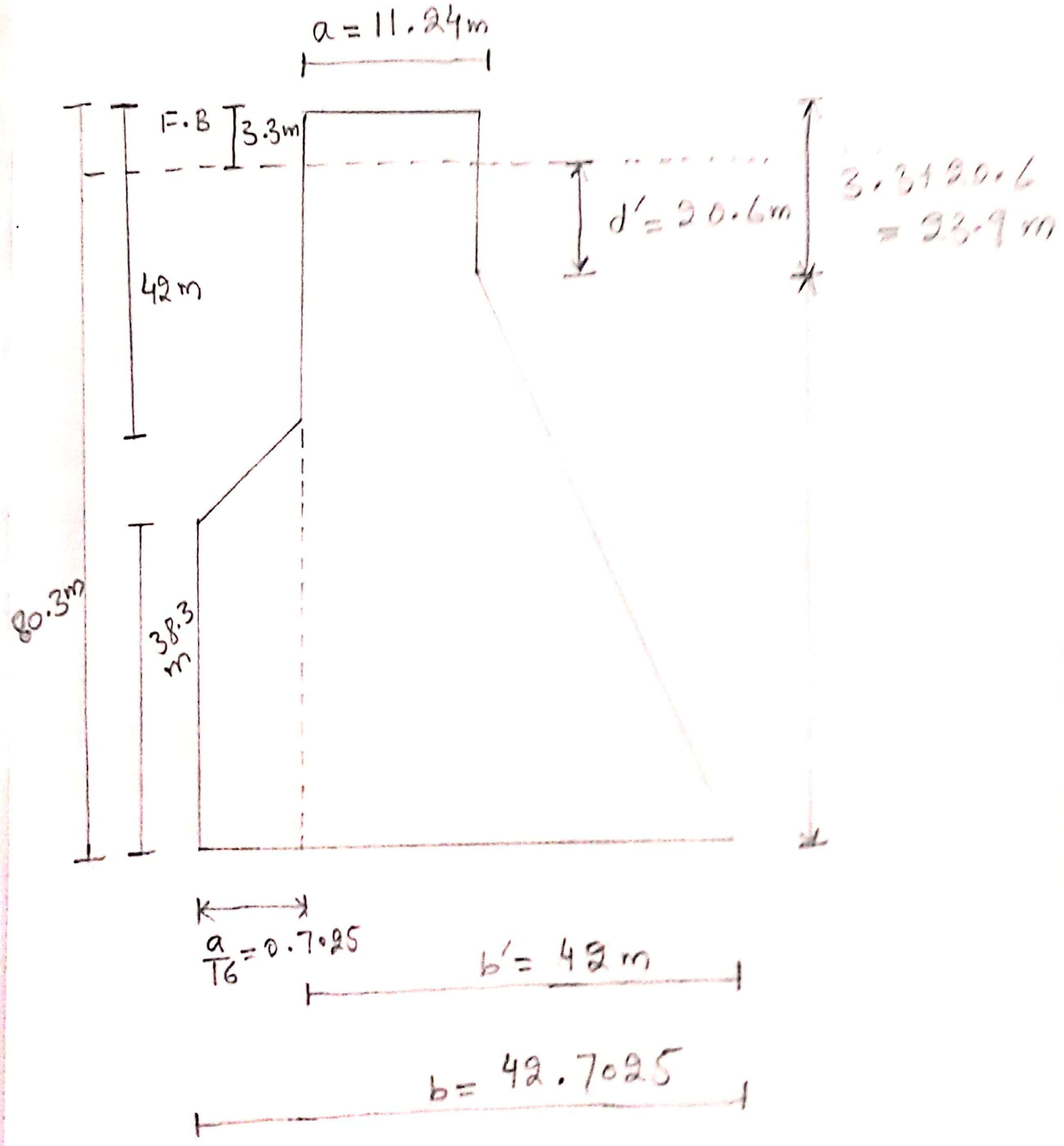
$d = d' + FB$

$d = 20.6 + 3.3$

$d = 23.9\ m$

$\boxed{d = 24\ m}$



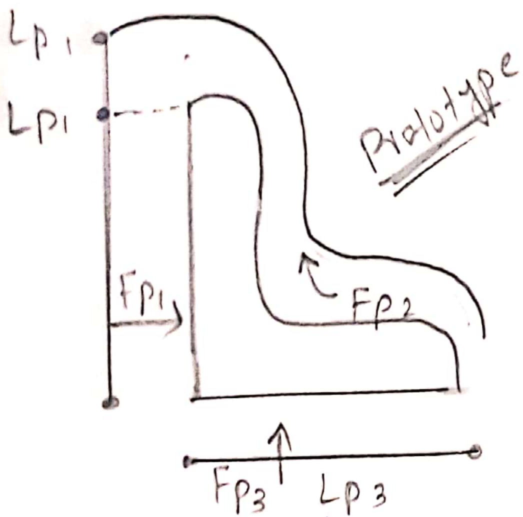
QNO. 3):

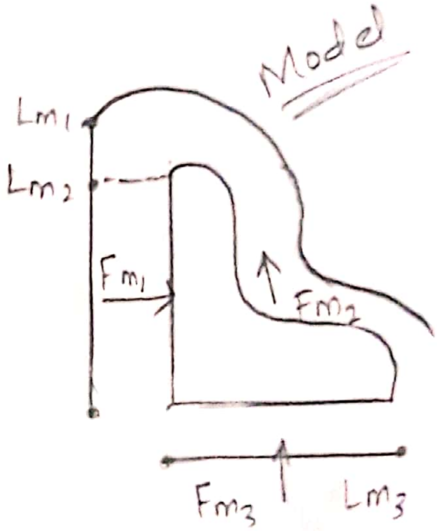
Ans:

Model Analysis:

Model: is a small scale replica of the actual structure.

Prototype: The actual structure or machine.





Mode Analysis: is actually an experimental method of finding solutions of complex flow problems.

The following are the advantages of model analysis.

→ Using dimensional analysis, a relationship between the variable influencing a flow problem is obtained which help in conducting test.

→ The performance of the hydraulic structure can be predicted in advance from its model.

→ The merits of alternative design can

be predicted in advance from its model analysis to adopt most economical and safe design.

Similitude: is defined as similarity between the model and prototype in every respect, which mean model and prototype have similar properties or model and prototype are completely similar.

Types:

- Geometric similarity
- Kinematic similarity
- Dynamic similarity.

Geometric similarity: The linear dimension in model and protype are equal.

$$\underbrace{\frac{L_p}{L_m}}_{\text{Length}} = \underbrace{\frac{B_p}{B_m}}_{\text{Breadth}} = \underbrace{\frac{D_p}{D_m}}_{\text{Diameter}} = \underbrace{L_r}_{\text{Scale ratio}}$$

Kinematic similarity: similarity of motion.

$$\underbrace{\frac{V_{p1}}{V_{m1}}}_{\text{velocity}} = \frac{V_{p2}}{V_{m2}} = \underbrace{V_r}_{\text{velocity ratio}} ; \quad \underbrace{\frac{a_{p1}}{a_{m1}}}_{\text{acceleration}} = \frac{a_{p2}}{a_{m2}} = \underbrace{a_r}_{\text{acceleration ratio}}$$

Dynamic similarity: similarity of force.

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$$\frac{(F_i)_p}{(F_i)_m} = \frac{(F_v)_p}{(F_v)_m} = \frac{(F_g)_p}{(F_g)_m} = F_r$$

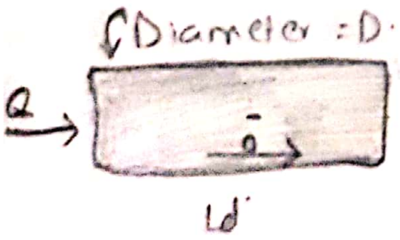
Inertia Force

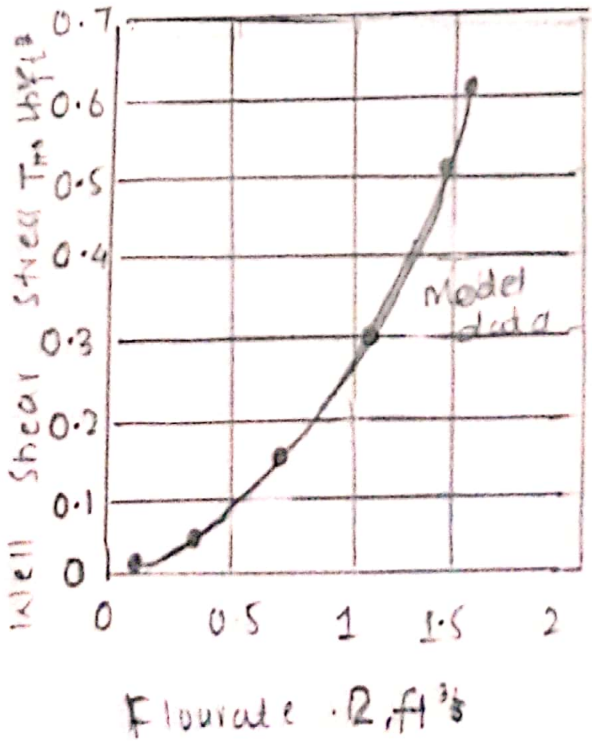
Viscous force

Gravitational force

Force ratio

Example: Assume that wall shear stress τ_w, created when a fluid flows through a pipe depends on the pipe diameter, D, flowrate Q, fluid density ρ and kinematic velocity ν. Some model test run in laboratory using water in a 0.2-ft diameter pipe yield the τ_w vs Q data shown in figure. Shear stress is 0.3 ft diameter pipe through which water flow at the rate of 1.5 ft³/s.





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Diamentional Analysis:

$\tau_w = f(\boxed{D, Q, \rho}, \nu)$ → repeating variables

$\tau_w = FL^{-2}$ $\quad D = L$ $\quad Q = L^3T^{-1}$

$\rho = FL^{-4}T^2$ $\quad \nu = L^2T^{-1}$

From pi theorem $5-3=2$ pi terms required and dimension analysis yields

$$\frac{\tau_w D^4}{\rho Q^2} = \phi\left(\frac{Q}{D\nu}\right)$$

Model Analysis:

The similarity requirement is

$$\frac{Q_m}{D_m\nu_m} = \frac{Q}{D\nu}$$

So that with $\nu_m = \nu$ and

$Q = 1.5\ ft^3/s$

$$Q_m\left(\frac{D_m}{D}\right)\left(\frac{\nu_m}{\nu}\right)Q = \left(\frac{0.2\,ft}{0.3ft}\right)(1)\left(1.5\frac{ft^3}{s}\right)$$

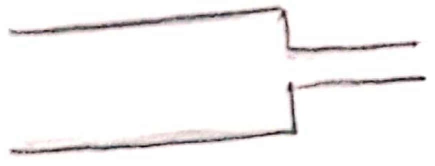
From graph $Q_m = 1.007\frac{ft^3}{s}$, $\tau_m = 0.29\frac{lb}{ft^2}$

Thus $\dfrac{\tau_{wm} D_m^4}{\rho_m Q_m^2} = \dfrac{\tau_w D^4}{\rho Q^2}$

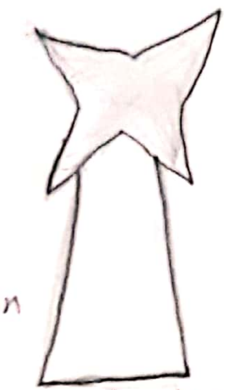
and $\tau_w = \left(\dfrac{\rho}{\rho_m}\right)\left(\dfrac{Q}{Q_m}\right)^2\left(\dfrac{D_m}{D}\right)^4\tau_{wm}$

$= (1)\left(\dfrac{1.5}{1.0}\right)^2\left(\dfrac{0.2}{0.3}\right)^4(0.29)$

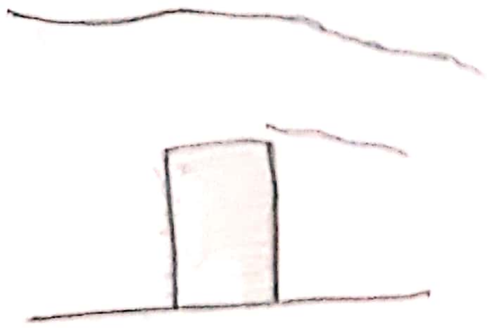
$= 0.129\ lb/ft^2$



sudden contraction in pipe



wind turbine



Dam /spillway

- Dimensional Analysis to predict the physical parameters that will significantly influence phenomenon under study.
- similitude and Model analysis to investigate the complexity of in details. phenomenon on
- Application of Knowledge actual/prototype model.

Methodology of Dimensional Analysis:

The basic principle is Dimensional homogeneity, which means the dimensions of each terms is an equation on both sides are equal.

so such an equation, in which dimensions of each term on both

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sides are equal, called dimensionally homogeneous equation.

$V = (2gH)^{1/2}$

$V = LT^{-1}$

$(2gH)^{\frac{1}{2}} = LT^{-1}$

L.H.S = R.H.S

so its dimensionall homogeneous

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QNO.4):

Ans:

FALL VELOCITY:

When a grain falls down in still water it obtains a constant velocity when the upward fluid drag force on the grain is equal to the downward submerged weight of the grain.

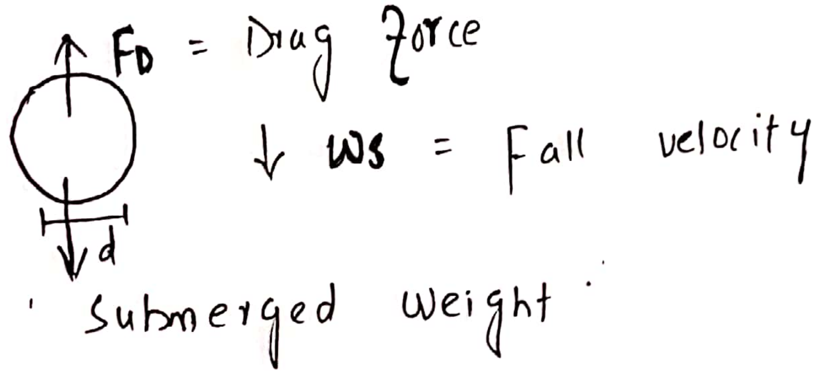
This constant velocity is defined as the fall velocity of the grain.

This is also called Setting velocity.

DEPENDENCE:

Fall velocity depends on;

(1) Particle diameter
(2) particle density.
(3) Particle concentration.
(4) Particle shape
(5) viscosity of water (temprature)
(6) Turbulence.



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The force balance b/w the drag force and the submerged weight gives

F_D = submerged weight.

(1) PARTICLE DIAMETER:

The diameter of the particle is directly proportional to the fow velocity because greater the size of particle so it will tends to move of particle so it will tends to move faster as compared to the particle of small size thus their will be move gravitiational force on particle of greater size so it will fall quickly due to its weight.

(2) PARTICLE DENSITY:

Density of the particle is directly proportional to the rate of fall velocity since particle with height density tends to settle down early compared with the particle of density.

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(6) <u>TURBULANCE OF WATER:</u>

Turbwance of water effect the fall velocity of water in reservior because the non- ~~linearity~~ linearity and zig zag path effect the flow of water and cause the variation in the flow.